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Abstract

Accelerator Department

Annual Progress Report

1 January 1973 - 31 December 1973

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CONTENTS

I. GENERAL INFORMATION

The objective of the Accelerator Department is to contribute to research, development, and realization of processes based on ionizing radiation. In order to fulfil this objective, the following activities are pursued:

- Operation and maintenance of the irradiation facilities (three electron accelerators and three ^{60}Co-units).
- Customer irradiation services for laboratories at and outside Risø, for hospitals, and for industrial companies.
- Irradiation technology studies, including upgrading of present facilities, development of new irradiation equipment, introduction of dose computation programs, and improvement of equipment and methods for customer irradiation services.
- Design and construction of equipment for radiation experiments.
- Radiation chemistry research in relation to systems applied in chemical dosimetry and pulse radiolysis of aqueous solutions. The pulse radiolysis research is carried out in close connection with the Chemistry Department.
- Radiation physics research in relation to systems applied for dose calibration and dose distribution measurements, mainly by new methods such as holography and interferometry.
- Radiation bacteriological research mainly in relation to radiation sterilization problems and radiation resistant microorganisms.
- Production and delivery through IAEA of bacteriological standard preparations for control of irradiation sterilization plants.
- International collaboration on the above-mentioned subjects, including IAEA research contracts and participation in international meetings and working groups. Bilateral collaboration arrangements are maintained with a number of scientific laboratories in Europe and in the United States.

II. EVENTS OF THE YEAR

The head of the department since 1965, Niels W. Holm, fil.dr., was promoted assistant director as from 1 October 1973. K. Schested is acting head of the department from that same date.

The "First Milestone" acceptance test for the new HRC Linear Accelerator will take place in January 1974, slightly behind schedule.

On behalf of the Danish Atomic Energy Commission, the Accelerator and Chemistry Departments hosted:

- The 3rd Polish-Danish Symposium on Radiation Chemistry, Risø 24-27 September 1973.

A research contract with the International Atomic Energy Agency (IAEA) concerning investigations on the behaviour of the Fe^{++}/Cu^{++} chemical dosimeter under process conditions, including the influence of solute concentrations on the system, was renewed.

A research contract with IAEA concerning investigations on the influence of dose rate and environment on the radiation resistance of highly resistant bacteria was completed in December 1973. Microbiological standard preparations for efficiency testings of medical radiation sterilization plants were prepared and issued according to this contract, and testings of four foreign industrial plants were carried out by the department in 1973.

A research agreement with IAEA concerning investigations on the microflora in the surroundings of reactors, irradiation plants, and other areas with a high level of irradiation over a long period of time was renewed.

Three staff members participated in an IAEA contractors' meeting in Budapest, Hungary, 13-18 February 1973. (IAEA RES. Contr. 973/RB). One staff member was visiting professor at the University of Maryland (U.S.A.) 2-16 April 1973, and one staff member is studying holographic and interferometric methods at the U.S. National Bureau of Standards (1 October 1973-1 October 1974). One staff member and one of the consultants (Dr. E.A. Christensen) were advisers for WHO in preparation of new recommendations for sterile products.

One staff member from the bacteriological group has left, and the position has been filled. One staff member (physicist) has left, and the position is vacant.

III. REPORT ON THE ACTIVITIES

III. 1. Operation and Maintenance of the Irradiation Facilities[x)]

a. The Electron Linear Accelerator

In the past year the accelerator was used for radiation chemistry mainly in connection with the use of the pulse radiolysis equipment, radiation microbiology research, and for customer irradiation services, e.g. radiography for the Metallurgy Department and radiation sterilization of special items for Scandinavian hospitals.

The operation of the linac has been intensive (2050 hours). Except for a short shut-down period of 6 days the linac has run satisfactorily. The spare klystron has malfunctioned and has been sent to U.S.A. for repair.

b. HRC Electron Linear Accelerator

According to the conditions of the contract for delivery of the new HRC accelerator the "First Milestone" acceptance test should have been completed in December, but has been postponed to January 1974. The "First Milestone" includes the 250 kV power supply, electron gun, DC accelerator column, and short pulse sweeper, which together represent the first stage of the accelerator.

In connection with the installation of the new accelerator a target room will be established. The Health Physics Department has calculated the X-ray transmission for different shielding materials for the wall between the target and the accelerator rooms and for the shielding labyrinth leading into the target room.

Design of the supports for the guntank and the accelerator waveguide is carried out by the Construction Department. Construction of a new stainless steel bending chamber is under progress in the same department.

Modifications of the present cooling water and cooling air system, power supply, etc. are under preparation in the Service Department.

c. The Field Emission Accelerator

The field emission accelerator, installed in 1968, was used for aqueous and gaseous radiation chemistry research, bacteriological research, and dosimetry development.

[x)] Technical specifications of the facilities are listed in Appendix 2.

There have been problems with the capacitor modules, and an inspection in May showed 16 defective modules. A new overhaul in October showed 11 defective modules. The Field Emission Corporation has been consulted for assistance, and the cheif engineer will visit the Accelerator Department in January for an inspection. The problems probably arise from too high humidity content in the insulating gas.

The old monochromator and sampler in the pulse radiolysis set-up have been replaced by equipment with better performance. (For further information please consult the annual report of the Chemistry Department).

d. The Low-Energy Electron Accelerator (ICT)

The low-energy electron accelerator was used for applied radiation chemistry studies (e.g. curing of surface coatings and polymer film modification) and for dosimetry research.

It has not been possible to obtain a high-purity nitrogen atmosphere in the target area in the present installation. If a particular atmosphere is wanted in an irradiation, the samples must be irradiated in available containers. This difficulty is the main reason for the low utilization of the installation.

The operation of the accelerator has been troublefree.

e. The 10,000 Ci ^{60}Co-Facility

The 10,000 Ci ^{60}Co-facility was used for radiation research and for customer services. It further serves as a reference source for microbiological efficiency testings according to IAEA's recommendations for the radiation sterilization of medical products.

Reloading to 11,000 Ci took place in January 1973. At the same time a general mechanical overhaul took place. During the rest of the year there has been no major repairs.

f. The 5,000 Ci ^{60}Co-Cell

The 5,000 Ci ^{60}Co-cell is presently located in the Control Department of Statens Seruminstitut, Copenhagen, where it has been used for bacteriological research.

The operation of the cell has been satisfactory, but as the sources have now decayed to 3,800 Ci, two new sources (4,000 Ci) will be supplied in the spring of 1974.

g. The 3,000 Ci ^{60}Co-Cell

The 3,000 Ci ^{60}Co-cell was used for research in radiation chemistry, radiation bacteriology, and radiation biology including mutation breeding.

Reloading to 3,7oo Ci took place in January 1973. Owing to attack on the source encapsulation by a corrosive liquid, the interior of the cell was contaminated and had to be cleaned thoroughly. The corrosion damage on the mechanical parts was repaired. To prevent future incidents with corrosive liquids a brass cylinder connected to the tubes through the top shield has been made. This cylinder is used in all irradiation of liquid systems. During the rest of the year the operation of the cell was satisfactory.

III. 2. Radiation Bacteriology Research

The bacteriological research work is directed towards the further development and realization of radiation sterilization processes in the broadest sense; while adequate procedures and techniques have been established for the radiation sterilization of a wide variety of single-use medical equipment made of polymer materials, assistance is often required for new or modified products. Substantial further development work is needed before the process can be applied in general to e.g. biological materials, pharmaceuticals, or articles of food. The limited resources of the bacteriological laboratory do not permit any overall development effort, and present and planned programmes therefore concentrate on providing fundamental bacteriological information of general relevance for these processes, and on assisting other laboratories and users on specific projects. The bacteriological laboratory maintains active collaboration with the International Atomic Energy Agency. Besides the research activities described below, the staff participated in IAEA panels and contractors' meetings.

a. Bacteriological Research Projects

A series of experiments has been carried out concerning the influence of environment and irradiation parameters on radiation inactivation of bacteria. lo MeV electrons have a lower inactivating efficiency than gamma rays on dried preparations with bacteria except for some noteworthy exceptions. Humidity has an influence on the radiation resistance of bacteria, but final conclusions with respect to the practical application of this knowledge cannot be drawn at present, except for the production of bacteriological standard preparations with Str. faecium, strain $A_2$1.

The investigations on the microflora in the surroundings of reactors, irradiation plants, and other areas with a high level of irradiation over a long period of time (IAEA Research Agreement No. 975/CF) were continued. The purpose of these investigations is to check on the change in radiation resistance of a natural microflora upon prolonged exposure to radiation. Investigations of a natural soil flora located in the immediate vicinity of an open-air 2o Ci ^{60}Co-source are carried out. Conclusive data are now at hand showing a significant increase in resistance for some of the strains.

The results of studies on post-irradiation DNA degradation in Micrococcus radiodurans, strain $R_{II}5$ were published by M. Auda (visiting IAEA scientist, November 197o - November 1971) and C. Emborg in Radiation Research. Another visiting IAEA scientist, S. Sudiro (October 1972 - September 1973) has in collaboration with the staff investigated variations in differences in response to electrons and gamma rays of a series of preparations of a sporeforming strain.

The comparison of the biological effects in rats of radiation sterilized and autoclave sterilized food has been finalized and the results published in Risø Report F 26o.

The department has maintained an interest in food irradiation through the association of the Danish Atomic Energy Commission with the NEA/IAEA food irradiation project in Karlsruhe. Research directly related to food irradiation is not carried out at the Accelerator Department for the time being.

At present there is only scarce knowledge concerning the radiation resistance of anaerobic microorganisms contaminating medical equipment and medical products. Preliminary experiments regarding the radiation resistance of such microorganisms have been initiated.

b. Production and Delivery of Microbiological Standard Preparations and Biological Indicators

The IAEA Recommendations for Radiation Sterilization of Medical Products request microbiological efficiency testings at the commissioning of a radiation sterilization plant by means of standard preparations of vegetative and sporeforming bacteria. Our bacteriological laboratory produces, delivers, and assays standard preparations of Str. faecium, strain $A_2$1, and B. sphaericus, strain C_IA, for this purpose according to an IAEA Research Contract (973/RB).

Biological indicators for the routine control of minimum doses of 2.5, 3.5, and 4.5 Mrads are delivered from the laboratory upon request. The indicators are based on selected radiation-induced mutants of B. cereus. The laboratory has participated in a performance test of biological indicators organized by the United States Pharmacopeial Convention Subcommittee on Biological Indicators.

c. Customer Services for Hospitals, Research Laboratories, and Industry

The following services are maintained on a routine basis:

- Sterilization services for Scandinavian hospitals, including general consulting, irradiation of test specimens, evaluation of materials and packagings, etc. in relation to the introduction of new hospital equipment.
- Experimental irradiation of medical products, pharmaceutical raw materials, fodders, and articles of food for industry and research laboratories, including assistance in planning of experiments, procurement of bacteriological data, etc.
- Development of initial counting techniques for new products and training of laboratory personnel in such techniques.

The investment in these services in terms of man power and machine hours is very limited, but the services appear to be much appreciated, particularly by the hospitals, with which good contacts have been maintained directly and through Dansk Centralsterilisationsklub.

III. 3. Chemical Dosimetry and Radiation Chemistry

The work within this area concerns:

- Performance of routine dosimetry in relation to irradiation experiments and customer irradiation services.
- Development and exploitation of new chemical dosimetry systems.
- Radiation chemistry and pulse radiolysis research, particularly on aqueous systems of interest to chemical dosimetry.

The research work concentrates on investigating the reaction mechanisms and kinetics of irradiated aqueous solutions with a view to obtaining better understanding of possibilities and limitations in the practical application of aqueous chemical dosimeters, and to contributing to radiation chemistry knowledge in general.

The radiation chemistry and pulse radiolysis research work progresses in collaboration with the Chemistry Department, Hilbert Christensen, Studsvik, Sweden, and Edwin Hart, Argonne, U.S.A.

a. Routine Dosimetry Services

Routine dosimetry was carried out in connection with customer irradiation services and irradiation experiments. After reloading of the 10,000 Ci ^{60}Co-facility and the 3,000 Ci ^{60}Co-cell a complete calibration was performed. The results are described in a report, Risø-M-1651.

b. Development of Chemical Dosimetry Systems

The research contract with IAEA (No. 1173/R1/RB) was renewed. The contract covers investigation on the behaviour of the Fe^{++}/Cu^{++} chemical dosimeter under process condition, including the influence of solute concentrations on the system.

The reaction scheme was tested by parameter studies. The results of our computations (O. Lang Rasmussen) were checked by comparison with computations made at Argonne National Laboratory (K. Schmidt). A series of pulse radiolysis experiments was performed in order to determine the rate constants for the reaction of Cu^{+} with O_2, Fe^{+++}, and H_2O_2. The results are reported in the IAEA progress reports.

The possibility of incorporating the aqueous Fe^{+++}/F^{-}-dosimeter in a gel was investigated. Preliminary experiments revealed difficulties in obtaining reproducible results, and it was decided for the moment to postpone further work on this subject.

c. Radiation Chemistry and Pulse Radiolysis Research

The determination of the "primary yields" in neutral and acid solutions was concluded with measurements in the H_2O_2-water system and with accurate determination of the H_2SO_5-yield in acid solutions. The results are published in Rad. Res. Vol. 56, No. 2, Nov. 1973. The attempt to determine the radical yields prior to the reactions taking place in the expanding spur (the total water decomposition yield) did not work out satisfactorily, because the experiments showed that pressures up to 100 ato probably are needed and the existing pressure cells can only be used up to 4o ato. The total yields were measured to be 8.o - 8.5, which is too low compared with the "theoretical" yield (9.5), but because of the lower pressure we did not quite reach a plateau.

The Danish-Swedish collaboration project (Hilbert Christensen and Knud Sehested) has resulted in a publication in J. Phys. Chem. Vol. 77, No. 8, 1973, concerning the benzyl radical and the acid-catalyzed water elimination reaction in irradiated toluene solutions. The hypothesis of such a reaction was proved and the rate constant was determined to be 1.1 $\times$ lo^{6}. Further it was found that OH and O^{-} react in different ways with toluene, the first one yielding the hexadienyl radical, the latter the benzyl radical. The investigations were extended to compounds with several methyl groups on the benzene nucleus, and rate constants and spectra were determined. The ratio of OH-radicals reacting by H-abstraction from the methyl groups and addition to the benzene ring is directly proportional to the number of methyl groups giving a rate constant for H-abstraction of 4 $\times$ lo^{8}. The O^{-}-rate constant is independent of number of methyl groups (2.5 $\times$ lo^{9}), probably a diffusion control H-abstraction reaction. The rate for water elimination in acid solution showed that other reaction steps than the protonation are rate determining. In this connection a new transient in acid solution was discovered. This transient is absorbing in the visible range and decays very fast. It is assigned to the carbonium ion radical. These results give a better understanding of the water elimination reaction, which weems to take place in three steps, starting with a charge transfer complex. This also explains why the reaction constants fitted a Hammet function plot. The results were presented at a meeting in Moscow, lo - 14 December 1973, and a publication is under preparation.

In connection with the work on methylated benzenes, benzenes in alkaline solution was irradiated and surprisingly only about 2/3 of the hexadienyl radicals are formed. An investigation of the phenyl radical was then undertaken as a collaboration project between Argonne National Laboratory, U.S.A., (E. Hart) and the Accelerator Department. The phenyl radical is formed from iodobenzene by reaction with electrons, but the experiments have revealed a lot of new information about the mechanism in iodobenzene including new transients and reactions. Special interest is paid to a species which we tentatively believe is a carbonium ion radical.

During the tenure of Dr. J. Sutherland his interest in gaseous systems in connection with airpollution caused in investigation of SO_2 in acid aqueous solution. Several rate constants and spectra were obtained and a reaction mechanism which is pH-dependent is being checked by measuring some major products such as H_2 and $S_2O_4^{--}$. Preliminary results and conclusions were presented at the Polish-Danish symposium in September.

The work on the pulse radiolysis of adrenaline (in collaboration with N. Getoff) was continued during a 2-month visit by a graduate student (M. Gohn). The work was concentrated on the identification of the spectra formed by the different primary species. Additional experiments are planned. Work on product determination will be done in Vienna (N. Getoff).

The work on detecting the O-atom optically by pulse radiolysis of perchlorate solutions was continued. In 8 M perchlorate there is an absorption at 230-260 nm which might be due to the O-atom. The work is continued using different scavengers in order to prove or disprove that the absorption can be assigned to an O-atom.

III. 4. Physical Dosimetry

The objective of the physical dosimetry activities is to investigate physical problems related to radiation research and processing, in particular

- to provide standardization equipment for dose calibration of the irradiation facilities, e.g. special irradiation geometries.
- to develop and exploit new physical dosimeter systems for routine use in radiation research and processing.

A number of calorimeters based on conventional temperature sensors have been produced for calibration of the facilities in different irradiation geometries over the years. A laser technique, measuring the changes in refractive index of irradiated solutions, has been introduced as a promising tool for dose and dose-distribution calibrations of electron beams.

The development program is directed mainly towards providing better experimental dose-distribution data to improve the monitoring techniques for straight beam experiments at the linear accelerator and at the field emission accelerator.

Close collaboration is maintained with the National Bureau of Standards, U.S.A. (W.L. McLaughlin).

a. Dose Calibration Activities

Calorimeters are available in some specific geometries for all the electron and gamma sources in the department.

The application of the laser technique for interferometric and holographic determination of dose and dose distributions in irradiated liquids has been demonstrated, and a collaboration arrangement with the National Bureau of Standards (W.L. McLaughlin) for refining and developing these techniques is continued at the National Bureau of Standards by a member from the Accelerator Department (one year). In the interferometric dose determination, the average temperature increase along a line through the electron-irradiated medium is measured in terms of the change in refractive index by means of a laser beam. The rise time is of the order of 1 μsec, and the sensitivity is better than 2×10^{-3} °C corresponding to a dose of one krad. In the holographic measurement, three-dimensional information on the temperature ($\sim$ dose) distribution can be obtained at some loss in sensitivity. Dose and dose-distribution determinations in geometries similar to those used in the pulse radiolysis work are performed. The results were presented at the Polish-Danish symposium in September. The system has been improved by measuring disturbances in introduced parallel fringes. In this way it is possible to detect events that would give less than one fringe in the old system. If the sensitivity can be improved by a factor of ten, one may have the possibility to measure directly the heat of reaction in some chemical systems.

b. Physical Dosimeters for Routine Use

PVC films and radiochromic dye films have been used extensively for dose and dose-distribution measurements of the scanned beam at the linear electron accelerator and at the low-energy electron accelerator respectively. Difficulties have been encountered in getting commercial radiochromic dye films of adequate quality, and it has been found necessary to calibrate each individual film dosimeter at a low dose. Much work has been devoted over the past year to preparing better films within the department, and usable types of film can be produced with difficulty. This project will not be extended because of lack of man power and difficulties in the preparation technique.

A performance test, including reproducibility, of a series of polymer and polymer-based dosimeters (PVC, Clear Perspex, Yellow Perspex, Red Perspex, Cellulosetriacetate, Blue Cellophane, and radiochromic dye films) has been carried out in collaboration with the National Bureau of Standards, U.S.A. The results were presented at the Polish-Danish symposium, September 1973, and a report is under preparation.

III. 5. Irradiation Technology

The objectives of the work are

- to provide experimental equipment and irradiation technology know-how for research and pilot plant projects carried out at the irradiation sources.
- to engage in development projects of relevance to the industrial exploitation of ionizing radiation.

The first objective is part of a continued effort to improve customer irradiation services in the broadest sense. Some attempts in this direction have already been described in the previous sections. The second objective is based on the philosophy that the availability of cheaper and more reliable low-energy electron accelerators could cause a substantial breakthrough in radiation chemical processing. A rather modest project was set up in contact with Danish industry to exploit the possibility of constructing a small and simple accelerator unit based on a cold cathode. The design aim is an electron beam energy of 2oo keV at a 5 mA current.

a. Experimental Equipment and Irradiation Technology Know-how

As previously, assistance regarding equipment and instrumentation was given to the various ongoing research projects.

The pulse radiolysis equipment at the linear electron accelerator was supplied with an automatic integrator determining the charge in each electron pulse. This charge is proportional to the dose deposited in the cell.

The dose distribution computation programs by Berger and Seltzer (NBS) turn out to be too big for an effective run on the Burroughs B 67oo Computer at Risø. The programs will instead be adapted for the Univac 111o computer at RECKU.

b. Development of a Cold-Cathode Accelerator

Adjustment of the beam current on a laboratory model by a variable resistor inserted between the grid and the cathode has been performed and seems to be very simple and reliable. Stable working conditions have been established at a low voltage (25% of the design voltage).

From experiments at higher voltages it turns out that the difficulties connected with the high voltage operation are to limit the highly ionized gas to an area outside the space between the anode and the cathode. The work has therefore been concentrated on the investigation of the properties of the ionized gas at the cathode hole, and on an optimization of the electrode geometry based on an electrical field plot.

At Fysisk Laboratorium II, DtH, the properties of the ionized gas have been discussed and a few experiments have been performed. At Stærkstrømslaboratoriet, DtH, a computer program for the determination of the electrical field has been prepared.

Based on these results a new design of the cathode is under construction in the department. A test is estimated to take place in February 1974.

After several discussions and considerations a joint project with the Metallurgy Department will be initiated in 1974 on the development of a prototype electron beam welder based on the cold-cathode principle.

Staff of the Accelerator Department

31 December 1973

Academic Staff

E. Bjergbakke	
C. Emborg	(left 30 April 1973)
K. Engvild	(employed from 1 December 1973)
W.H. Eriksen	
J. Fenger	
J.W. Hansen	
P. Hjortenberg	(left 15 November 1973)
N.W. Holm	(Ass. Director from 1 October 1973)
J. Holcman	
B. Lynggård	
A. Miller	(p.t. U.S.A.)
K. Sehested	(Acting Head from 1 October 1973)
P.E. Simonsen	

Technical Staff

M. Elm Andersen	
S.B. Andersen	
H. Corfitzen	
I. Hansen	
L. Højlund Pedersen	(left 28 February 1973)
T. Johansen	
E. Engholm Larsen	
F. Larsen	
B. Nielsen	
L. Nielsen	
W. Nielsen	
P.B. Pedersen	
K. Pejtersen	
M. Wille	

Office Staff

E. Haugaard	
I. Ibsen	(left 30 June 1973)
R. Madsen	

Consultants

Dr. E.A. Christensen, Chief Physician, Control Department Statens Seruminstitut, Copenhagen.

Dr. E. Hart, Chemistry Division, Argonne National Laboratory, U.S.A.

Dr. W.L. McLaughlin, Applied Radiation Division, National Bureau of Standards, Washington, D.C., U.S.A.

Prof. J. Silverman, Laboratory for Radiation and Polymer Science, University of Maryland, U.S.A.

Visiting Scientists

S. Fidan, Turkey (25 September 1972 - 2 February 1973).

L. Kocsar, National Institute of Radiobiology and Hygiene, Budapest, Hungary (25 - 31 March 1973).

J. Sutherland, Brookhaven National Laboratory, L.I., U.S.A. (2 August 1972 - 15 July 1973).

S. Sudiro (IAEA stipendiate), Indonesia (1o October 1972 - 3o August 1973).

M. Gohn, Institut für Radiumforschung und Kernphysik, Vienna, Austria (1 September - 26 October 1973).

E. Hart, Chemistry Division, Argonne National Laboratory, U.S.A. (15 - 28 September 1973).

W.L. McLaughlin, National Bureau of Standards, Washington, D.C., U.S.A. (21 September - 8 October 1973).

E. Martin Fielden, Department of Physics, Institute of Cancer Research, England (25 - 27 November 1973).

Visiting Students

M. Zagorska, Poland (4 July - 28 August 1973).

M. Draganić, Yugoslavia (5 July - 12 September 1973).

Irradiation Facilities at the Accelerator Department

Electron Accelerators

1. Linear Electron Accelerator, Varian Ass., Model V-7700

Specifications:

Electron energy	10 MeV
Average electron current	550 µA
Peak electron current	330 mA
Pulse length	0.2-7 µsec
Pulse repetition rates	single pulses and 1 to 300 pps.
Scan width of bent beam	40 cm

The linear accelerator, which was installed in 1960, has over the years logged approx. 45,000 hours of operation. Facilities are available for process irradiation and for a variety of research applications including pulse spectroscopy and X-ray experiments.

2. Field Emission Electron Accelerator, Febetron Model 705B

Specifications:

Electron energy	0.5-2.0 MeV
Peak electron current	4000 A
Pulse length (electron mode)	20 nsec

3. Low-Energy Electron Accelerator, High Voltage Eng. Corp., Model EPS 400-IND

Specifications:

Electron energy	400 keV
Electron current	50 mA
Scan width	120 cm

The accelerator, which was installed in 1970, is supplied with conveyors to permit pilot-plant testing of dye curing processes and polymer film modification processes.

^{60}Co-facilities

1o,000 Ci ^{60}Co-facility (built at Risø 1957

The facility is designed for very homogeneous irradiation of samples with a maximum length of 1,000 mm and diameters of maximum 180, 100, or 60 mm. The corresponding maximum dose rates (10,000 Ci, 1 January 1974) are 5.6×10^5 rads/h, 1.44×10^6 rads/h, and 3.5×10^6 rads/h respectively. A report describing the facility and the calibration (together with the 3,000 Ci ^{60}Co-cell) has been published, Risø-M-1651.

5,000 Ci ^{60}Co-cell (built at Risø 1971)

The facility, which is designed for laboratory use, is fitted with a 123 mm$^{\varnothing}$ x 150 mm irradiation chamber. The dose rate in the centre of the chamber (3,800 Ci, 1 January 1974) is 3.1×10^5 rads/h. The cell is located at the Control Department, Statens Seruminstitut, Copenhagen. Reloading to about 7,000 Ci will take place in the spring of 1974.

3,000 Ci ^{60}Co-cell (built at Risø 1968)

The facility, which is designed for laboratory use, is fitted with a 120 mm$^{\varnothing}$ x 200 mm irradiation chamber. The dose rate in the centre of the chamber (3,300 Ci, 1 January 1974) is 3.2×10^5 rads/h. A report describing the cell and the calibration (together with the 10,000Ci ^{60}Co-facility) has been published, Risø-M-1651.

Lectures and Publications

Lectures

Ebbe A. Christensen, Radiation Induced Mutants. IAEA Research Coordination Meeting on Radiation Sterilization of Medical Materials and Biological Tissues, Budapest, Hungary (14-16 February 1973).

W.H. Eriksen (co-author C. Emborg), Draft Report on Some Preliminary Investigations of a Natural Soil Flora Located in the Immediate Vicinity of an Open-Air 2o Ci ^{60}Co-Source. IAEA Research Coordination Meeting on Radiation Sterilization of Medical Materials and Biological Tissues, Budapest, Hungary (14-16 February 1973).

Hanne Kristensen (Statens Seruminstitut), Isolation of Radiation Resistant Microorganisms from the Environments of ^{60}Co-Sources; Preliminary Results. IAEA Research Coordination Meeting on Radiation Sterilization of Medical Materials and Biological Tissues, Budapest, Hungary (14-16 February 1973).

Hanne Kristensen (Statens Seruminstitut), Radiation Resistant Microorganisms in Irradiated Soil; Preliminary Results. IAEA Research Coordination Meeting on Radiation Sterilization of Medical Materials and Biological Tissues, Budapest, Hungary (14-16 February 1973).

P. Hjortenberg and W.L. McLaughlin, Use of Radiochromic Dye Systems for Dosimetry. Regional Conference on Radiation Protection, Jerusalem, Israel (5-8 March 1973).

Ebbe Ahrensburg Christensen, Biological Indicators as Reference Standards for Various Sterilization Methods. Symposium on Sterilization and Sterility Testing of Biological Substances, Madrid, Spain (9-13 April 1973).

P. Hjortenberg and W.L. McLaughlin, Use of Radiochromic Dye Systems for Dosimetry. Nordisk Forening for Klinisk Fysik, Gausdal, Norway, (12-17 June 1973).

J. Sutherland, Radiation Chemistry of Aqueous Hydrazine Solutions, Risø (27 June 1973).

L.B. Sztanyik, Radiation Sterilization and the Role of IAEA, Risø (16 July 1973).

A. Miller, Absolute Measurements of Dose and Dose Distribution at Electron Accelerators by Means of Holography. 4. årsmøde i Nordiska Föreningen för Strålingsforskning och Strålingsteknologi, Otnäs, Finland (19-21 August 1973).

W.H. Eriksen, Radiation Induced Changes in a Natural Soil Bacterial Flora. 3rd Polish-Danish Symposium on Radiation Chemistry, Risø (24-27 September 1973).

J. Fenger, The Haimson Research Corporation Linear Accelerator to be Delivered to Risø in 1975. 3rd Polish-Danish Symposium on Radiation Chemistry, Risø (24-27 September 1973).

E. Hart, Picosecond Radiation Chemistry. 3rd Polish-Danish Symposium on Radiation Chemistry, Risø (24-27 September 1973).

A. Miller, Comparison of Industrially Used Film Dosimeter Systems. 3rd Polish-Danish Symposium on Radiation Chemistry, Risø (24-27 September 1973).

K. Sehested, Pulse Radiolysis of SO_2 in Aqueous Solutions. 3rd Polish-Danish Symposium on Radiation Chemistry, Risø (24-27 September 1973).

E.M. Fielden, Superoxide Dismutase, An Application of Pulse Radiolysis and epr to Biochemistry, Risø (26 November 1973),

K. Sehested, Pulse Radiolysis of Aqueous Solutions of Polymethylated Benzenes. Symposium on Radiation Chemistry of Aqueous Systems, Moscow, USSR (1o-14 December 1973).

Publications

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